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OVERVIEW OF DIFFERENT MPPT TECHNIQUE IN PHOTOVOLTAIC

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ABSTRACT

Temperature and sun radiation varies nonlinearly. Photovoltaic generation varies with reference to radiation and temperature. To gain maximum energy is very essential. MPPT are used to harvest maximum energy throughout the whole day [4-6]. A various technique of MPPT is used to gain large solar energy. In this paper, a various technique of MPPT has been discussed with considering different evaluating parameter like complexity, cost, a speed of conversion, adaptability, tracking ability, sensed parameter, an initial parameter required etc. Thus this paper gives the idea and further scope in MPPT technique for efficiency enhancement of solar photovoltaic.

KEYWORDS: Solar Photo Voltaic (PV) Systems, MPPT, Algorithms, Renewable, Modeling, I & C, P & O, Adaptive, Fuzzy Logic, Fractional, Instantaneous, PSO & GA

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Original Article

INTRODUCTION

Non-Renewable sources are now depleting day by day so utilization of renewable sources is very essential. [1]. To achieve maximum solar energy in photovoltaic, Various MPPT technique are used nowadays. Each method has different convergence speed, cost, and complexity, sensors, adaptability & tracking ability. So it is difficult to define particular method for specific application.[11] various methods with their features, advantages, and disadvantages are mentioned. It concludes with primary attributes of various strategies regarding many-sided quality, the required sensors, and their exactness, the speed of conversion, cost etc. Different methods are categorized as P & O, I & C, FLC, FOCV and SCC Instantaneous resistance, Genetic algorithm, Particle swarm optimization, novel technique, adaptive step size I & C, adaptive P & O, current based approach[1, 3, 4, 5, 7, 9, 10, 11, 12, 13,15, 24]

Numerous systems have been created to conquer these fluctuations and keep up the generation at most extreme power point. Analysts have created numerous procedures MPPT is the most ideal approach to achieve the greatest generation from photovoltaic. In MPPT, different calculations are utilized to extract the yield voltage and current estimations of the solar photovoltaic. This paper clarifies the different MPPT systems, records their points of interest and disservices It will fill in as a kind of perspective paper for additionally works in solar photovoltaic. Paper is composed of the different segment: segment 1explain introduction segment 2 clarifies the scientific displaying of PV cell and its characteristic Segment 3 clarifies MPPT and the need of MPPT. In segment 4 different MPPT systems like as P & O,I & C, FLC, FOCV, SCC, Instantaneous resistance, novel voltage technique, adaptive step size I &C, adaptive P & O, Genetic technique, particle swarm optimization etc. are explained and their merits and demerits are enumerated. In segment 5 detailed comparison of the various

techniques studied is presented in tabular form.

SOLAR CELL MODELING AND ITS CHARACTERISTIC

Cell Modeling

Sunlight based cell electrical model can be spoken to utilizing diode, opposition (arrangement and shunt)[4,6] as delineated in Figure 1

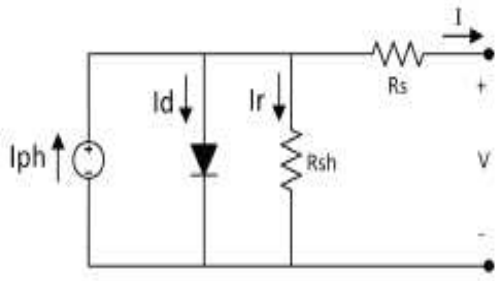

Figure 1: Solar Cell Model

Load current can be described as,

$$I = I_{ph} - I_d - I_r \tag{1}$$

Due to photovoltaic effect current generated is $I_{ph,}$ diode current I_d and current in shunt resistance is Ir. photovoltaic current is dependent on solar irradiance and T.

$$I_{ph} = [I_{ph,stc} + K_i(T - T_{stc})]\frac{G}{G_{stc}} \tag{2}$$

the photovoltaic current produced at standard test condition is I_{ph}, stc temperature coefficient is K_i, at 25°C temperature is T_{stc}, at $1000W/m^2$ radiation is G_{stc}. I_d is dependent on k, q, a1, n as per

$$I_D = I_0\left\{exp\left(\frac{q\,X(V+IXR_s)}{n_s XkXTXa_1}\right) - 1\right\} \tag{3}$$

Saturation current dependent on K_i, I_{scstc}, V_{ocstc} and K_v

$$I_0 = I_{s,stc} + k_i(T - T_{stc})exp\left[\frac{q\left(V_{oc,stc}+kv(T-T_{stc})\right)}{n_s xKxT}\right] \tag{4}$$

Two imperative parameters are has to ascertain which matches computed greatest power point to the exploratory most extreme power point ($Vmp \times Imp$).

Output Characteristic of PV Array

PV cell have low power and voltage rating so for practical application cells are always connected in series or parallel to get required voltage and power. The output characteristic of PV array under uniform solar irradiation [2] can be expressed by the following equation:

$$I^M = N_p I_{ph}^c - N_p I_s^c\left\{exp\left(\frac{\frac{V^M}{N_s}+\frac{I^M R_s}{N_p}}{V_t}\right) - 1\right\} - \frac{\left(\frac{N_p V^M}{N_s}+IR_s\right)}{R_{sh}} \tag{5}$$

$$V_t = \frac{nKT}{q} \quad (6)$$

The subscript M show PV modules, the subscript C demonstrate PV cell N_p show parallel cell and Ns show arrangement/series cell. An a rray of solar cell has the same characteristic as the solar cell.

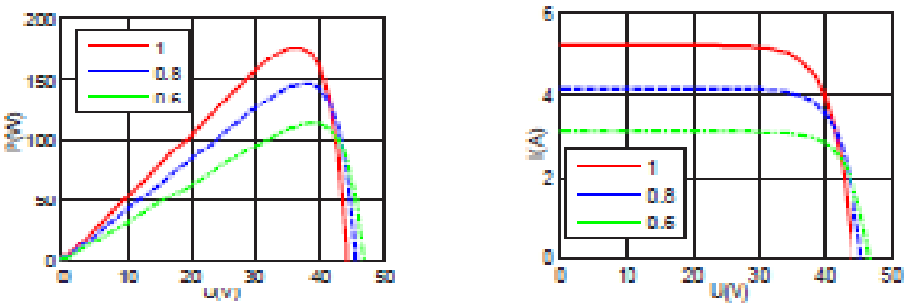

Figure 2: IV-Characteristic of PV Array PV-Characteristic of PV Array

MPPT AND ITS NEED

MPPT

MPPT figuring is imperative in PV applications in light of the way that the MPP of a daylight based module shifts with the enlightenment and temperature. The best power following framework makes use of estimation and electronic equipment. The instrument relies upon the government of impedance coordinating among load and PV module, which is vital for most prominent power transfer [23]. By changing the duty cycle of converter impedance of the solar module and load can match. (d) The switch. Figure 3 exhibits a clear DC to DC converter used for MPPT. The automated controller that drives the converter errand with MPPT limit. The power from the sunlight based module is registered by evaluating the voltage and current. This power is the contribution to a controller which alters the obligation cycle of the switch, realizing the adjustment of the reflected load impedance as indicated by the power yield of PV module and impedance of the load (R_L) reflected at the input side (R_i) of a buck type DC to DC converter can be given as

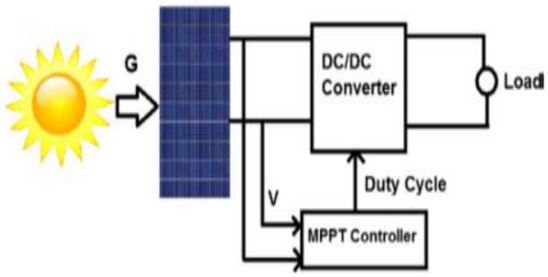

Figure 3: MPPT Controller Block Schematic

$$V_o = V_i \times d \quad (7)$$

$$R_i = \frac{R_L}{d^2} \quad (8)$$

Where d is the obligation cycle. By altering the obligation cycle, can be changed which ought to be the same as the impedance of sun based PV module in a given working condition for most extreme power exchange.

DIFFERENT MPPT TECHNIQUE

Perturb & Observe Algorithm:[4, 23]

P & O method compares the latest power and previous power. An optimum point can be located by measuring difference power is zero. The duty cycle of PWM gives P & O methodology. Duty cycle will be increased when recent power is larger than previous power and same way for duty cycle decrement steady state oscillation is more and voltage variation is more. P & O take long following time and slow response to the weather variation.

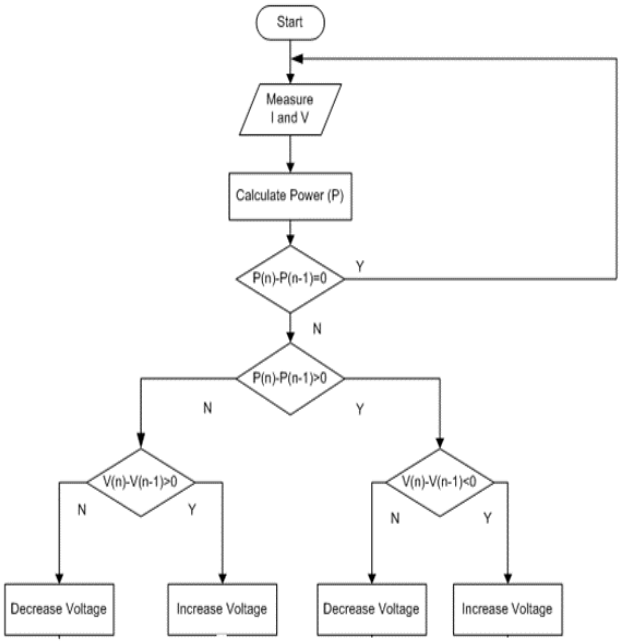

Figure 4: P & O

I & C Technique

The burden of P & O strategy is overwhelmed by Incremental &Conductance technique. In the Incremental and Conductance calculation differentiation of the power w. r. t. voltage so we can track the greatest power point. The calculation makes utilization of the condition

$$\frac{dp}{dv} = I + V\,\frac{dI}{dv} \tag{9}$$

At maximum power point,

$$\frac{dp}{dv} = 0 \tag{10}$$

$$-\frac{I}{V} = \frac{dI}{dV} \tag{11}$$

Above equations we get,

$$\frac{dI}{dV} = -\frac{I}{V}; \left(\frac{dP}{dV} = 0\right) \tag{12}$$

$$\frac{dI}{dV} > -\frac{I}{V};\ \left(\frac{dP}{dV} > 0\right) \tag{13}$$

$$\frac{dI}{dV} < -\frac{I}{V}; \quad \left(\frac{dP}{dV} < 0\right) \tag{14}$$

I & C stop their working when MPPT locates its MPP points. When MPP point is not located then algorithm find the relation between dI/dV and $-I/V$. dP/dV is negative when MPP is to the right and vice versa compared to P & O method, I & C method has very less oscillation because of MPP location

$$\frac{\Delta V}{\Delta P} = 0 \ \left(\frac{\Delta I}{\Delta P} = 0\right) \text{ at the MPP} \tag{15}$$

$$\frac{\Delta V}{\Delta P} > 0 \ \left(\frac{\Delta I}{\Delta P} < 0\right) \text{ at the MPP} \tag{16}$$

$$\frac{\Delta V}{\Delta P} < 0 \ \left(\frac{\Delta I}{\Delta P} > 0\right) \text{ at the MPP} \tag{17}$$

Incremental and conductance can track quickly expanding and diminishing irradiance conditions with higher exactness than perturb and observe. One burden of this calculation is the increased complexity when contrasted with Perturb and Observe.

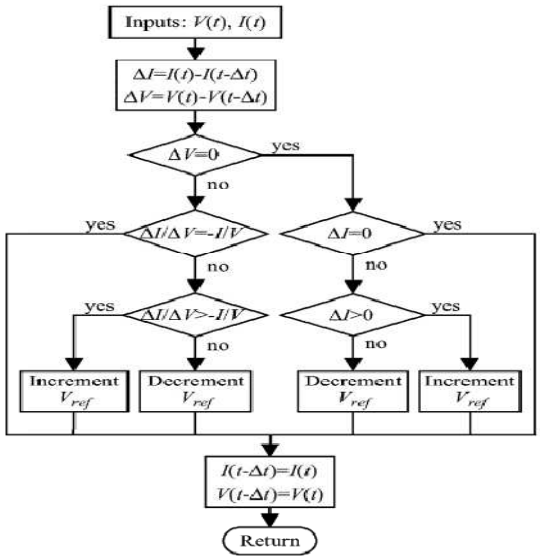

Figure 5: I & C Technique

FLC

FLC executed in solar panel to separates the maximum power. It is simple and more beneficial than another method [1, 8, 16, and 23]

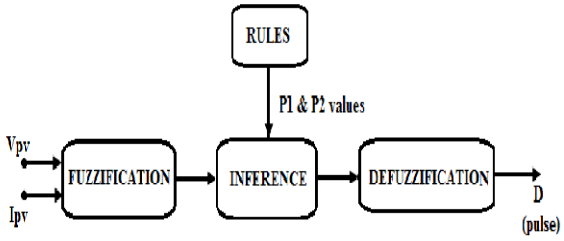

Figure 6: Fuzzy Logic Control Algorithm

FLC has executed remembering the true objective of union the MPPT computation with consistent temperature and sun based radiation. Power/current and voltage/current are the inputs for the FLC which modify the output power according to solar irradiance. Enrollment work for the fluffy rationale controller figured by the measure of voltage and power took after from the FLC has executed remembering the true objective to incorporate the MPPT estimation with steady temperature and sun oriented illumination. The voltage and current are sensed form Photovoltaic panel from which FLC function are derived. In perspective of these voltage and power regards following function can be

$$D_{(t)} = \frac{P_{pv(t)} - P_{pv(t-1)}}{V_{pv(t)} - V_{pv(t-1)}} \quad (18)$$

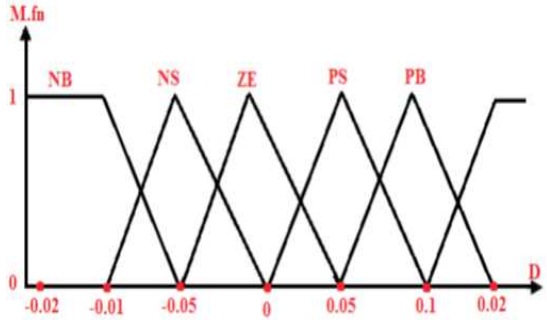

Figure 7: Mapping of V & I for Photovoltaic

$$CD_{(T)} = D(t) - D(t-1) \quad (19)$$

Where, P_{pv}– immediate generation of the power, $D_{(t)}$ – the value of error and CD(t) – change in error value for photovoltaic. Mapping of V & I for change in T & Radiation is in Figure 7 for different value of k MPPT direction is decided either left or right depending upon value is negative or positive. The greatest P & V can be followed in view of the error and variable k estimation of photovoltaic at the specific moment of day and age. Based on the duty cycle acquired from the FLC the converter either on or off occurs, this voltage is given to load via inverter.

FOCV

A FOCV procedure is extraordinarily outstanding MPP method for following. The crucial positive conditions of this methodology are low multifaceted nature and basic use (V sensor only). The action of FOCV system relies upon the way that the maximum voltage has straight association with the Voc for various light and temperature levels. The FOCV measures the maximum voltage by measuring [9] the open circuit yield voltage and increasing it by voltage factor. The estimation performed intermittently by quickly separating the load and estimating the voltage. These brief separations give loss of intensity. Time duration and f are specifically impact the accuracy of the evaluated maximum voltage. A slight alteration of this strategy can beat issue by utilizing extra cell which is like different solar cells in PV cluster and is completely committed for measurement.

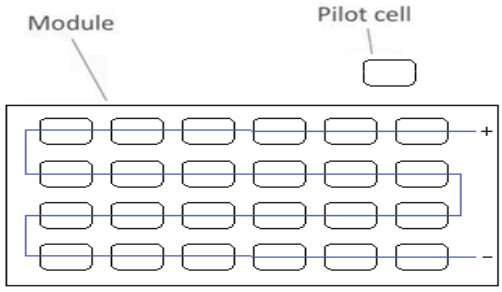

Figure 8: PV Module with Pilot Cell

In this method, it is supposed that single cell is at the same weather variation as other cells are. Continuous open circuit voltage measurement is done without removing the module from the measurement. Single cell is isolated from the whole PV module to measure continuous Voc. So that single cell cannot generate power in output.

VMPP=Kpv *Voc

Maximum voltage is the assessed greatest voltage, Voc is the deliberate open circuit voltage of the module and K_{pv} is a factor of voltage. Voltage factor can be decided from PV module characteristic depend upon weather variation. Voltage factor based upon different PV module technology and cells utilization.

Current Based Approach for MPPT

Complete approach consists module,controller and converter with battery. V & I are sensed into current based technique. This technique provides a reference as a current for tracking power point in current base approach. Controller give signal to converter switch for pulse setting.

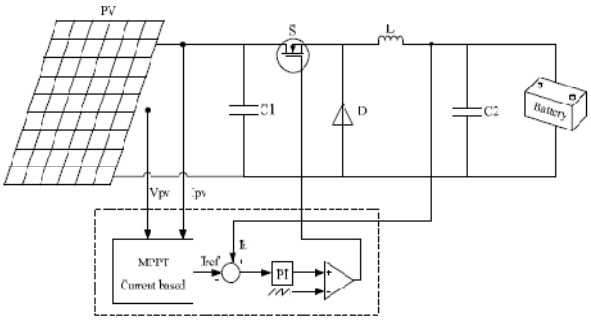

Figure 9: The Proposed System

Instantaneous Resistance MPPT

In this method ratio of V_{inst}/I_{inst} is to be calculated which is R_{inst}. For maximum power in all weather condition, R_{inst} has single/unique value. For achieving this condition power w. r. t instantaneous resistance slope is made to zero. All types of checks are made simple and more effective method to adopt. Complete drift problem is avoided in this method and characteristic will improve in this method. For different radiation derivative power curve is shown w. r. t instantaneous resistance. Aderivative of power w. r. t instantaneous resistance is greater than zero on left side of curve and is less than zero on right side of the curve.

$\frac{dP}{dRinst}=0$ at maximum point

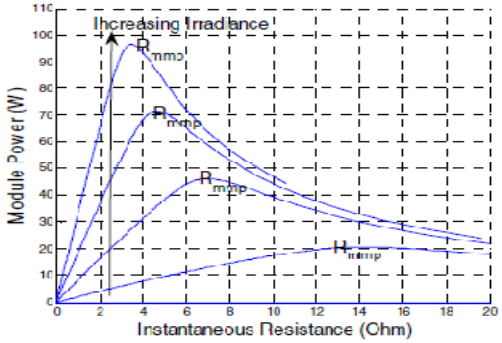

Figure 10: Power with Instantaneous Resistance with Varying Irradiance

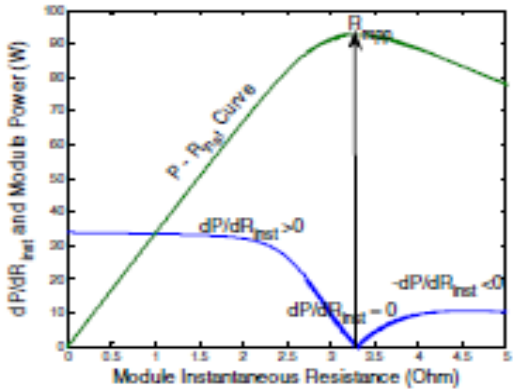

Figure 11: Power with dP/dR_{inst}

GA for MPPT

This algorithm uses vast spaces for optimization. Natural biological method of selection is used for survival of the fittest. Different number of samples individually represents solution. Cross breeding process has been done for generation. Those who are not capable they die out and remaining will exist. From new generation, best member is selected to carry forward the heredity of good characteristic. So that good features are passed down from one generation to other which is the best solution.

Particle Swarm based Optimization (PSO)

- N samples are introduced haphazardly in a hunt space.
- From N samples, the i_{th} molecule is picked and its wellness esteem is assessed in light of the goal work.
- If singular wellness estimation of this arrangement beats its previous one, at that point its P_{best}, i esteem is refreshed [14, 21].
- Every molecule is assessed on basis of current and future value.
- Best value from individual samples is selected and global best value is selected using equation(24)
- Each samples position and velocity is updated using equation(22) & (23)
- Iterations of this methodology are continued until the point when the moment that a particular blending

establishment is gone to The standard PSO conditions are given in (20) and (21):

$$V_i(K+1) = wV_i(K) + L_1 rand_1 \quad (20)$$

$$P_{best,i} - X_i(K) + L_1 rand_2\left(Gbest - X_i(K)\right) \quad (21)$$

$$V_i(K+1) = wV_i(K) + L_1 rand_1 \quad (22)$$

$$X_i(K+1) = X_i(K) + V_i(K+1) \quad (23)$$

$$G_{best} = MAX\{P_{best,i\ ,i=1,2,3.....N}\} \quad (24)$$

w=inertia weight, L_1= mental expanding speed coefficient, L_2 = social stimulating coefficient, rand1, r and 2 = sporadic numbers between (0, 1) appropriated reliably

$P_{best,i}$ = particular best health estimation of i_{th} particle

G_{best} = overall best health estimation everything considered

K = present accentuation number

$V_i(K)$ = i_{th} atom speed in existing revolving around cycle

$V_i(K + 1)$ = i_{th} atom speed in next revolving around cycle

$X_i(K)$ = i_{th} atom position in existing circumnavigating cycle

$X_i(K + 1)$ = i_{th} atom position in next revolving around cycle

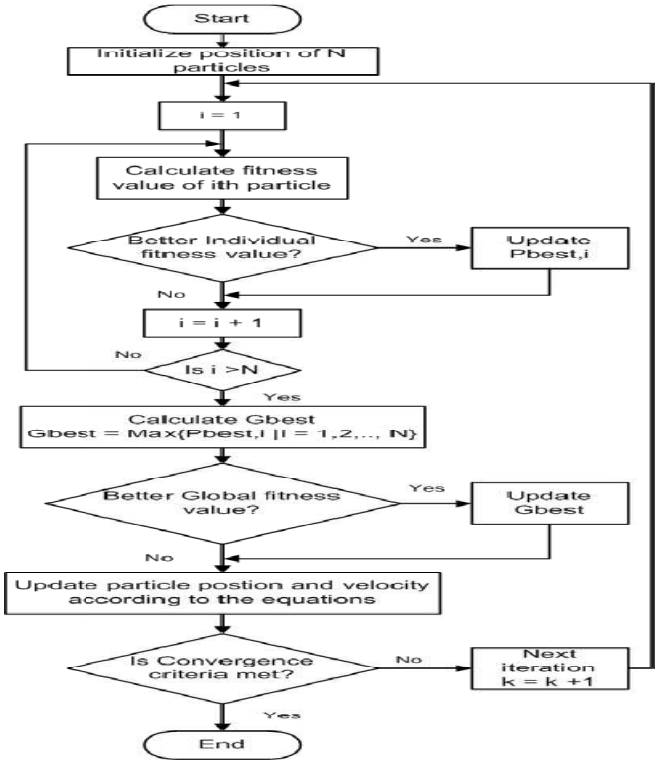

Figure 12: Particle Swam based Optimization

Novel Technique for MPPT

The most extraordinary power point following figuring relies upon the best power trade theory. Solar variation is identified by sensor. Panel voltage is sensed and current is defined by the following equation.

$$V_{out} = \frac{V_{in}}{1-D} \quad (25)$$

V_{out} – converter voltage

V_{in}: converter input, D- Converter duty cycle

$$I_{out} = \frac{I_{in}}{1-D} \quad (26)$$

Input side resistance is

$$R_{in} = (1 - D_2) * R_L \quad (27)$$

Impedance should be matched for maximum power transferring. So junction resistance should be equal to load resistance. In system continuous temperature and radiation is observed and duty cycle will change according to that.

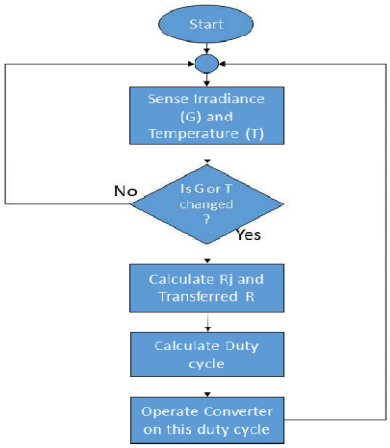

Figure 13: Novel Technique for MPPT

Reference based MPPT Algorithm

This method is useful in stand-alone system for maintaining energy generation and transfer from source to load. This method also used in grid connected system when low voltage generation from a system is required [10].

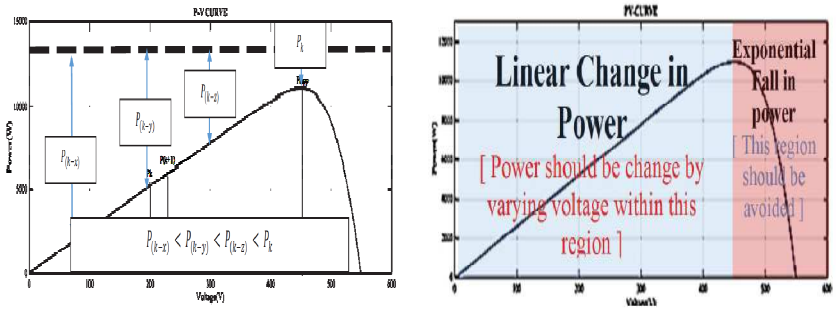

Figure 14: Reference based MPPT

There is a linear change in power from 0V to maximum voltage and there is the exponential change in power from maximum voltage to open circuit voltage as shown in a graph. This method perturbs the input voltage in proper direction to track the reference power. This method can be classified on basis of the reference power. If reference power is more than maximum power than system catch the maximum power based on irradiation. When reference power is less than maximum power, then controller change the voltage to track the reference power from 0W to maximum power with taking consideration of voltage boundary from 0V to maximum voltage. As shown in graph of figure 15 when reference power is less than maximum power than whole region is divided into four regions, which is also shown in the flow chart of figure 16

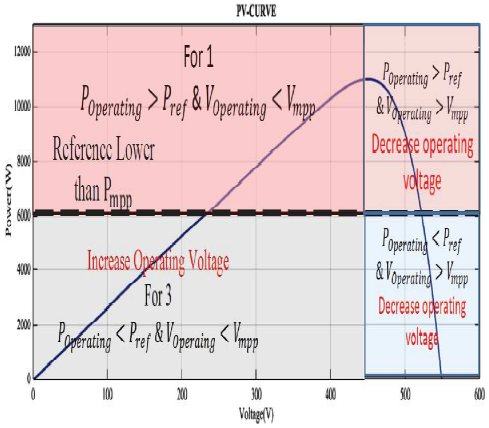

Figure 15: Reference based MPPT below P_{mpp}

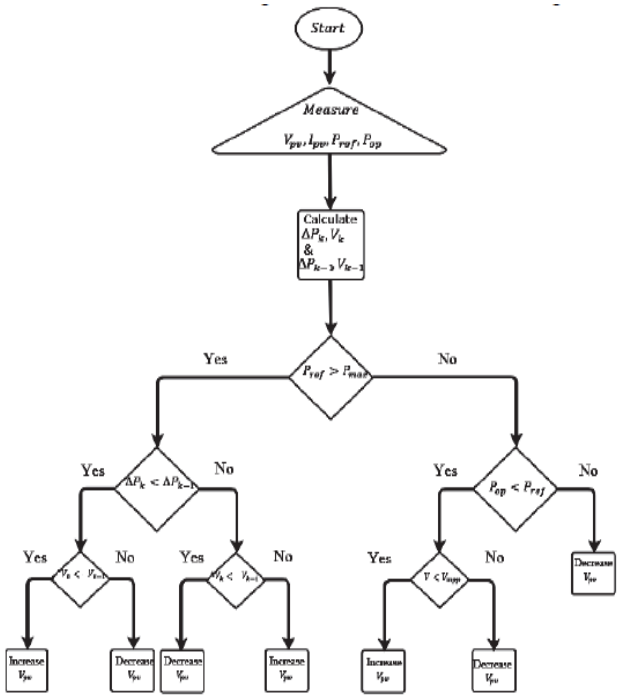

Figure 16: Reference based MPPT Flowchart

DC – CDC

When photovoltaic system is connected to the AC system then this method is used to control the voltage using a capacitor in DC link. d of the converter is :

$$d = 1 - \left(\frac{V}{V_{link}}\right) \quad (28)$$

V: photovoltaic voltage

In this method controlling is done by analog circuit. This method does not consume any power from photovoltaic system. This method is known as DC-capacitor droop control method. This method is used to control in voltage source application.

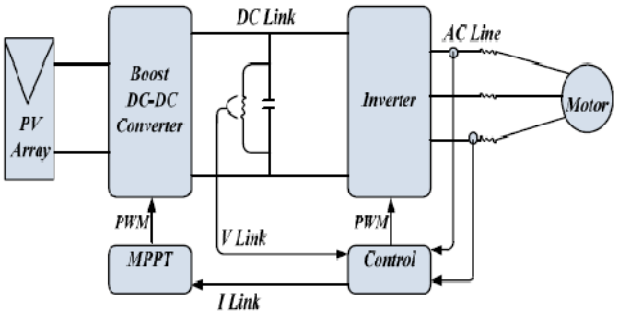

Figure 17: Block Schematic

Adaptive P & O Method

This technique is completely based on the power-voltage curve of photovoltaic. In this curve, slope factor is known as β. Ratio of change in power w.r.to change in voltage is known as the adaptive concept which is considered with sign. So slope factor can be decided with considering the sign of ratio, from which adaptive factor can be decided.

if $\frac{\Delta Ppv}{\Delta Vpv} > 0$, $Assigns\ large\ constant\ to\ \beta$

$\frac{\Delta p_{pv}}{\Delta V_{pv}} < 0, assigns\ small\ constant\ to\ \beta$

Adaptive factor α as:

$\alpha = \beta \frac{\Delta Ppv}{\Delta Vpv}$ adaptive step size voltage as $\Delta' as$

$$\Delta V' = \alpha \Delta V fixed$$

Δ*Vfixed* = fixed voltage step. So new voltage can be derived from an old voltage with the addition to step voltage.

$$\Delta Vnew = \Delta Vold + \Delta V'$$

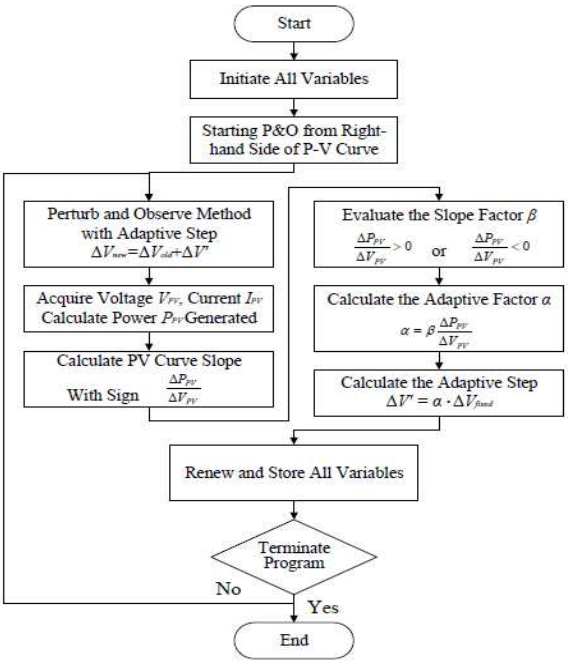

Figure 18: Adaptive P & O

Adaptive Step Size Incremental Conductance Algorithm

In this method ratio of change in current to the change in voltage is to be measured,which is known as conductance. This conductance is compared with instantaneous conductance for every instant. Reference voltage is incremented if IC is negative than instantaneous conductance and vice versa. In conventional IC(incremental conductance) method step size is not fixed but the varying value which changes w.r.t change in conductance. This adaptive step size can be defined as :

S*exp{M*abs(ΔI/ΔV)

M : fixed value of a multiplication

when the reference voltage is far away from maximum power point than step size is larger and it is closer than step size is smaller. So that accuracy is best and speed is also high. When conductance is –I/V then perturbing is stop and maximum point is achieved.

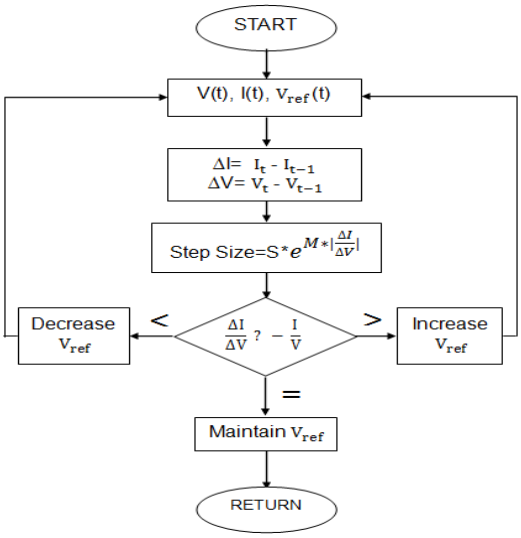

Figure 19: Adaptive Step Size Incremental Conductance

FSCC (ISC)

Maximum or peak current can be defined as:

$$Impp = K \times Isc \quad (29)$$

Constant K is approximately 0.78 to 0.92

k can be decided by photovoltaic system

In this method, short circuit current should be measured periodically by sensor. Which is same as open circuit voltage method. In this technique, one more switch is required so cost is higher than open circuit voltage method. An approximation can be used for measuring environmental parameter variation. Isc can be as:

$$Isc = Isc1 \times (G / G1) + a1 \times (T - T1) \quad (30)$$

REVIEW OF MPPT TECHNIQUE

A lot of research has been led to enhance the proficiency of sunlight based following frameworks. It is vital to pick the most reasonable MPPT in light of elements like precision in foreseeing the genuine MPP, cost, merging pace and affectability, intricacy, following capacity, exhibit reliant, intermittent tuning, detected parameter, starting parameter. MPPT techniques[12], for example, Fractional Open Circuit Voltage (VOC), fuzzy rationale control, current based advancement, quick opposition, molecule swarm enhancement, hereditary calculation, novel system, reference-based method, DC interface capacitor hang control, versatile P and O, versatile advance size I &C are examined and near investigation is given in Table.1 for various parameter.

CONCLUSIONS

Productive utilization of solar module is to separate its greatest power age with the assistance of MPPT is principle target of this paper. Numerical model for PV cell is clarified and the requirement for MPPT to accomplish most extreme power yield is talked about with the assistance of output characteristic. An Arrangement of different MPPT procedure is talked about with favorable circumstances, impediments and approach. At long last, an aggregation of

different MPPT procedures based on control variable, cost, unpredictability level, tracking capacity, exhibit needy, intermittent tuning, detected a parameter, starting parameter are talked about. This paper will fill in as a source of perspective paper for the future work for proficiency improvement utilizing MPPT method.

Table 1

MPPT Technique	Cluster Dependent	A/D	Frequent Tracking	Variable to Sense	Starting Parameter	Convergence Capacity	Difficult	Sensitivity	able to Track
P & O	No	Both	No	V	No	varies	low	medium	yes
I & C	Yes	Digital	No	V,I	Yes	Varies	medium	medium	yes
FLC	No	Digital	Yes	V,I	yes	medium	High	High	yes
FOCV	Yes	Both	Yes	I	yes	medium	low	low	no
Short circuit current	yes	both	Yes	I	yes	medium	medium	low	no
Current base	Yes	Both	Yes	I	yes	low	high	medium	no
Instantaneous resistance	yes	both	yes	V,I	yes	medium	high	medium	yes
PSO	No	Digital	No	V,I	yes	fast	low	high	yes
GA	No	Digital	No	V,I	yes	fast	high	high	yes
DC link capa. droop	No	Both	No	V	yes	medium	low	medium	medium
Adaptive P & O	No	Digital	No	V,I	yes	high	medium	medium	yes
Adaptive step size I & C	yes	digital	No	V,I	yes	high than I & C	medium	Medium	yes

REFERENCES

1. *Woonki Na and Pengyuan Chen, Jonghoon Kim, Hong-Ju Jung[2016], "Improved maximum power point tracking algorithm using a Fuzzy Logic Controller for a Photovoltaic System"2016 IEEE 7th International Symposium on Power Electronics for Distributed Generation Systems (PEDG)Year: 2016 Pages: 1 – 5*
2. *WANG Bing, HU Qingyi, CHEN Junma[2016], "Multiple peaks maximum power point tracking of photovoltaic arrays based on the jumping strategy Proceedings of the 35th Chinese Control Conference July 27-29, 2016, Chengdu, China*
3. *F. E. Tahiri; K. Chikh; M. Khafallah, A. Saad[2016], "Comparative study between two Maximum Power Point Tracking techniques for photovoltaic system 2016 International Conference on Electrical and Information Technologies (ICEIT) Pages: 107 - 112 Referenced in: IEEE Conferences*
4. *Rahul G. Suryavanshiu, Sonal R. Suyravanshi Diwakar R. Joshi, Rudresh B. Meghdum[2015], "Maximum power point tracking of SPV at varying atmospheric condition using Genetic Algorithm" International Conference on Energy Systems and Applications (ICESA 2015) Dr. D. Y. Patil Institute of Engineering and Technology, Pune, India 30 Oct - 01 Nov, 2015 @ IEEE*
5. *Su Sheng, Brad Lehman[2016], "A Simple Variable Step Size Method for Maximum Power Point Tracking Using Commercial Current Mode Control DC-DC Regulators" 2016 IEEE Applied Power Electronics Conference and Exposition (APEC) ,Year: 2016 ,Pages: 2286 - 2291*
6. *Pedro H. F. Moraes, Bruno de A. Fernandes, Aylton J. Alves, Wesley P. Calixto, Geovanne P. Furrie[2016], "Simulation and analysis of an isolated full-bridge DC/DC boost converter operating with a modified perturb and observe maximum power point tracking algorithm 2016 IEEE 16th International Conference on Environment and Electrical Engineering (EEEIC)*
7. *Harshal Deopare; Amruta Deshpande[2015], "Modeling and simulation of Incremental conductance Maximum Power Point tracking 2015 International Conference on Energy Systems and Applications Year: 2015 Pages: 501 - 505 IEEE Conferences*
8. *Shilpa Sreekumar, Anish Benny[2013] "Fuzzy Logic Controller Based Maximum Power Point Tracking of Photovoltaic System Using Boost Converter" 4th ICCCNT 2013 July 4-6, 2013, Tiruchengode, India IEEE – 31661*

9. *D. Baimel, R. Shkoury L. Elbaz S. Tapuchi N. Baimel[2016], "Novel optimized method for maximum power point tracking in PV systems using Fractional Open Circuit Voltage technique 2016 International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM) Year: 2016 Pages: 889 - 8594 @IEEE*

10. *Prof. Dhaval Y. Raval , Prof. Pratik J. Munjani, Prof. Nasreen R. Mansoori (2016) "Reference based Maximum Power Point Tracking Algorithm for photo-voltaic power generation" International Conference on Electrical Power and Energy Systems (ICEPES)Maulana Azad National Institute of Technology, Bhopal, India. Dec 14-16, 2016@IEEE*

11. *Mostafa Jalalian Ebrahimi[2015], " General overview of maximum power point tracking methods for photovoltaic power generation systems" 30th Power System Conference (PSC2015), 23-25 November 2015, IEEE 2015*

12. *Azzouzi, M. E. S. S. A. O. U. D. A., and M. I. L. A. N. Stork. "Modelling and simulation of a photovoltaic cell considering single-diode model" Recent Advances in Environmental Science and Biomedicine (2014): 175-182.*

13. *Vidhya K Viswambaran, Dr. Arfan Ghani and Dr. Erping Zhou[2016], "Modelling and simulation of maximum power point tracking algorithms & review of MPPT techniques for PV applications" Electronic Devices, Systems and Applications (ICEDSA), 2016 5th International Conference IEEE 2016*

14. *Mohammad Jobayer Hossain, Bibek Tiwari, and Indranil Bhattacharya[2016], "An adaptive step size incremental conductance method for faster maximum power point tracking Photovoltaic Specialists Conference (PVSC), 2016 IEEE 43rd IEEE 2016*

15. *Tong Guan, Fang Zhuo[2017], "An improved SA-PSO global maximum power point tracking method of photovoltaic system under partial shading" Environment and Electrical Engineering and 2017 IEEE Industrial and Commercial Power Systems Europe (EEEIC / I&CPS Europe), 2017 IEEE International Conference.*

16. *Chavaree Thueanpangthaim, Patumporn Wongyai, Kongpan Areerak* and Kongpol Areerak[2017], "The maximum power point tracking for stand-alone photovoltaic system using current based approach 5th International Electrical Engineering Congress,Pattaya,Thailand,8-10,IEEE 2017*

17. *Tuna Nahak,Yash Pal[2016], "Comparison between conventional, and advance maximum power point tracking techniques for photovoltaic power system" Power India International Conference (PIICON), 2016 IEEE 7th*

18. *T. Halder[2016], "A maximum power point tracker (MPPT) using the incremental conductance (INC) technique" Power Electronics (IICPE), 2016 7th India International Conference on 2016 IEEE*

19. *Shiena Kundu, Nikita Gupta, Parmod Kumar[2016] "Review of Solar Photovoltaic Maximum Power Point Tracking Techniques" 2016 7th India International Conference on Power Electronics (IICPE)Year: 2016Pages: 1 – 6 IEEE Conferences*

20. *Shanifa Beevi S. Johnson Mathew Vincent G.[2016] "A high performance instantaneous resistance maximum power point tracking algorithm" 2016 7th India International Conference on Power Electronics (IICPE)*

21. *Raghuram Munasala, T Padmavathi[2017] "Analysis of Maximum Power Point Tracking techniques for Photo Voltaic System" 2017 International Conference on Algorithms, Methodology, Models and Applications in Emerging Technologies (ICAMMAET) Year: 2017 Pages: 1 – 5 IEEE Conferences*

22. *Saurabh Gavali, Amruta Deshpande "Particle swarm based optimization algorithm for maximum power point tracking in photovoltaic (PV) systems" 2017 2nd IEEE International Conference On Recent Trends In Electronics Information & Communication Technology, May 19-20, 2017, India page no. 1584-1586*

23. *Prisma Megantoro, Fransisco Danang Wijaya, Eka Firmansyah [2017], "Analyze and optimization of genetic algorithm implemented on maximum power point tracking technique for PV system" 2017 International Seminar on Application for Technology of Information and Communication (iSemantic) Year: 2017 Pages: 79 - 84 Referenced in: IEEE Conferences*

24. *Chetan Singh Solanki, "Solar photovoltaic: fundamentals, Technologies and Application, PHI publication, Third Edition, April 2015.*

25. *Hala J. El Khozondar, Rifa J. El Khozondar, Khaled Matter, Teuvo Suntio(2016). "A review study of photovoltaic array maximum power tracking algorithms", Renewable: wind, water and solar Springer open journal Vol.3,pp.1-8.*